Synchrotron Microtomography at ALS

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A microtomography system is being designed and fabricated for nondestructive microstructural characterization and internal dimensioning at small length scales.

The objective of this project was to design and install an x-ray microtomography system for the dedicated CT beam line at the Advanced Light Source (ALS) facility at LBNL. The microtomography system is intended to provide nondestructive characterization of microstructure, and internal dimensioning of samples and components at small length scales. The microtomography system consists of translation and rotational stages; a lens-coupled camera-based imaging system; and data acquisition and control software. It was designed to obtain spatial resolution as small as 1 to 2 µm, with parallel beam geometry at x-ray energies in the range 4 to 140 keV.

During the past year, the data acquisition software was rewritten to reduce electronic overhead involved with camera readout and stage motion; a new structure for supporting, housing, and aligning the imaging detector (camera and scintillator) was designed, built, and tested; image tiling software was developed to handle samples of larger diameter than the field of view; and a number of application results were obtained to test and demonstrate system capability with the system fielded at the Stanford Synchrotron Radiation Laboratory (SSRL).

To take full advantage of the high brightness of the synchrotron source, the data acquisition software was significantly modified by using onboard features of the camera, resulting in a data acquisition process that is fully asynchronous. With these modifications, the acquisition software, which remains compatible with our existing laboratory capabilities, is no longer the

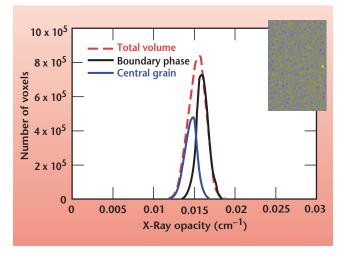


Figure 1. Tomographic image of a cylinder of LX17 high explosive obtained at SSRL.

rate-limiting step in data acquisition. Extensive modifications were also made to the camera and scintillator mounting designs to improve alignment and to ease the alignment process.

Imaging specimens of importance to LLNL programs (high explosives, shock spallation, and laser targets specimens) provided an important test of the new system design. High-explosive samples were imaged with microtomography for the first time allowing particle and boundary phases of the explosive to be separated and analyzed (Fig. 1).

High quality 3-D images of the microstructure of shock spallation samples were obtained which show both void morphology and particle size distribution (Fig. 2). A new tiling algorithm that enables imaging of large diameter specimens at high spatial resolution was designed and tested on aerogel witness plates being used in the debris-shield mitigation program for protecting laser optics. Laser-ruled targets were imaged and reconstructed in 3-D to determine the as-machined rule pattern periodicity and groove depths.

Among problems that have benefited from synchrotron tomography, and are in urgent need of the greater precision this beam line will allow, are 3-omega damage studies, shock spallation studies, high-energy-density target characterization, and high-explosive aging.

We anticipate that the full capabilities of the system will be demonstrated at ALS in February 2003. Significant improvements in image resolution and contrast and extended capabilities are expected since the beam divergence and beam intensity at ALS are both improved by nearly a factor of 10 compared to SSRL; x-ray energies extend to nearly a factor of 5 higher; and new contrast mechanisms, such as phase contrast, can be explored.

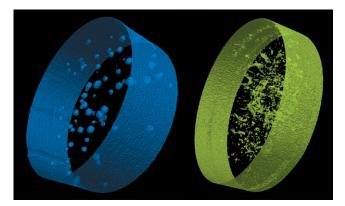


Figure 2. High-quality images of the microstructure in shock spallation experiments, from synchrotron microtomography. Image on the left is a 3-D representation of the internal void structure in a single crystal aluminum cylinder that was shocked in the LLNL gas gun facility. On the right is the corresponding image from a polycrystalline specimen.